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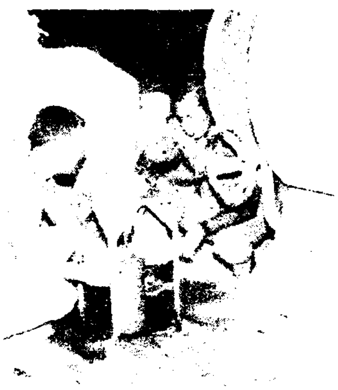

STRUCTURES LABORATORY

TECHNICAL REPORT SL-92-20

QUALITY ASSURANCE PLAN FOR PLACEMENT OF COLD-CAP GROUT, DEMONSTRATION VAULT, HANFORD GROUT VAULT PROGRAM

by

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13. ABSTRACT *(Maximum 200 words)*

During FY 91, the U.S. Army Engineer Waterways Experiment Station (WES) developed a grout to be used as a cold cap, a nonradioactive layer, between the solidified waste and the cover blocks of a demonstration waste disposal vault at the U.S. Department of Energy Hanford Facility. This document recommends requirements for a quality assurance (QA) plan for field mixing and placing of the cold-cap grout during final closure of the demonstration vault.

Preplacement activities emphasize selection and testing of materials that will match the performance of materials used in the WES grout. Materials sources and applicable American Society of Testing and Materials, American Concrete Institute, and American Petroleum Institute specifications and requirements are provided. Archiving of physical samples of materials is essential, in addition to careful maintenance of test reports and laboratory data. Full-scale field trial mixing and a detailed preconstruction conference are recommended.

(Continued)

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Placement activities focus on production and placement of a grout that remains sufficiently constant throughout all batches and meets performance requirements. QA activities must be coordinated between the batch plant and delivery site. Recommended sampling during placement includes cylinders cast for subsequent tests of compressive strength and for nondestructive evaluation and prisms cast for monitoring volume stability. A minimum of two lifts is recommended.

Postplacement activities include long-term monitoring of the properties of grout specimens cast during placement. Minimum testing of cylinders includes pulse velocity, fundamental frequency, and unconfined compressive strength. Monitoring characteristics of the microstructure also are recommended.

The QA plan should designate an organization to have responsibility for maintaining complete records, reports, and archived samples, including details of deviations from plans written before field placement.

PREFACE

The work described in this report is part of an ongoing research effort accomplished in the Concrete Technology Division (CTD), Structures Laboratory (SL), U.S. Army Engineer Waterways Experiment Station (WES), under Interagency Agreement from the Department of Energy Field Office, Oak Ridge (DOE/OR), No. DE-AI05-90OR21921. Mr. Earl McDaniel, Oak Ridge National Laboratory, is the Technical Monitor of this work which was performed in support of the U.S. DOE Hanford Grout Vault Program.

This report contains recommendations to the U.S. DOE Hanford Grout Vault Program concerning quality assurance measures during field placement of cold-cap grout.

The effort was accomplished under the direction of Mr. Bryant Mather, Director, SL, WES, and Mr. Kenneth Saucier, Chief, CTD, SL. This report was written by CPT Patrick T. Harrington, Dr. Lillian D. Wakeley, LTC James J. Ernzen, and Mr. Donald M. Walley. Messrs. John A. Boa, Jr., and Hugh K. Wilson also participated in this effort. Dr. Wakeley was Principal Investigator for the Hanford cold-cap grout development project at WES, of which this report is one product.

Westinghouse Hanford Corporation (WHC) is responsible for the Hanford Grout Vault Program. Messrs. Jeff Voogd and Kenneth Bledsoe, WHC, reviewed and commented on this document during its preparation.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Leonard G. Hassell, EN.

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CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
Fahrenheit degrees	5/9	Celsius degrees or kelvins*
gallons	3.785412	litres
inches	25.4	millimetres
cubic feet	0.02832	cubic metres

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

QUALITY ASSURANCE PLAN FOR PLACEMENT OF COLD-CAP GROUT, DEMONSTRATION VAULT, HANFORD GROUT VAULT PROGRAM

Background

1. The Hanford Grout Vault Program was developed for permanent disposal of radioactive wastes generated by defense activities at the Department of Energy (DOE) Hanford Facility (WA). This facility has been in use and producing radioactive wastes since the 1940's. It is currently operated for the DOE by Westinghouse Hanford Corporation (WHC).

2. Plans for the Grout Vault Program call for the wastes to be removed from temporary underground tanks, mixed with dry-blended components of the wasteform grout, and then pumped into underground concrete vaults. Wasteform grout developed for what is known at Hanford as "phosphate-sulfate waste (PSW)" was formulated in the late 1980's, and pumped into a demonstration vault at Hanford in 1988 and 1989.

3. In 1991, the WES developed a nonradioactive grout to be used to fill the space between the PSW grout and the cover blocks of the demonstration vault, to be placed during vault closure operations. Grout requirements and development are reported elsewhere (Wakeley, et al. 1992; Wakeley and Ernzen 1992a,b).

4. During 1992, the WES continued to support those aspects of the Hanford Grout Vault Program that involved plans for closure of the demonstration vault with the WES cold-cap grout. This report was prepared to describe quality assurance requirements recognized by WES experts as essential to successful field placement of a grout developed and verified in laboratory studies.

Scope

5. This report recommends necessary actions to ensure placement operations for the Hanford demonstration vault cold-cap grout with a material

exhibiting properties as predicted by laboratory research. Tasks described herein will ensure adequate documentation of the origins of the materials and their performance. Documentation will also provide correlation between laboratory predictions and actual field performance of materials. This plan is in three sections; preplacement, placement, and postplacement activities.

6. The tasks described by this plan are recommendations to stress the minimum requirements for quality assurance (QA) measures for the finished grout material. This document will not substitute as a comprehensive QA System, which should be developed by the facility owner in coordination with all contractors and subcontractors. A comprehensive QA plan or system should as a minimum (American Concrete Institute (ACI) 121R-85) define the owner's policy objectives, scope of work, organizational relationships, authority, and responsibilities for all concerned with the task of cold-cap placement.

7. We recommend the final QA plan should stipulate that Westinghouse Hanford Corporation (WHC) have sole responsibility and final authority during all operations involving placement of the cold cap grout. As facility operator, WHC should develop a comprehensive QA system incorporating the tasks in this document. The U.S. Army Engineer Waterways Experiment Station (WES) scientists and engineers are available for consultation during all phases of the operation. We recommend that representatives of the WES Concrete Technology Division be onsite during the placement and postplacement phases to offer technical observations about grout properties or about any onsite adjustments to the grout mixture.

Preplacement Activities

8. Preplacement activities will include tasks necessary to ensure minimum variability among batches and to produce grout with properties adequately similar to laboratory results of mixture performance. Minimum tasks include characterization, storage, and handling procedures of materials and identification of contractor's experience, equipment, and capabilities. To meet grout performance objectives, all parties involved with grout mixing and placement must understand their roles and responsibilities prior to placement. These parties include but are not limited to WHC, the

contractor(s), materials suppliers, quality control inspectors, and safety inspectors. Possibly the most important subtask during all phases of grout placement is detailed and specific documentation of each task performed.

Starting materials

9. Mixture components must not be significantly different from those prescribed in the WES draft report (Wakeley and Ernzen 1992b). We recommend the same sources of component materials be used as were used during cold-cap grout development by WES. A list of these materials and sources is in Appendix A. Regardless of the sources from which materials are procured, all mixture components should meet minimum specifications stated below to limit variability in final grout properties.

10. The cement must be an American Petroleum Institute (API) standard oil-well high sulfate-resistant (HSR) type. We recommend a Class H (HSR) oil-well cement, which was the same class and type used in our laboratory testing. Chemical and physical characteristics of low tricalcium aluminate (C_3A) and high cement coarseness are characteristic of all API (HSR) standard oil-well cements. The important requirement is that the cement class, type, and brand chosen for placement activities meet API specifications and match the performance of the cement used in the cold-cap grout developed by the WES.

11. Silica-rich sand from Hanford as specified in the WES report is the required fine aggregate for the cold-cap grout. Grading requirements should match size No. 2 natural sand specification of the American Society for Testing and Materials (ASTM) C 404, "Standard Specification for Aggregates for Masonry Grout," with material retained on the 2.36-mm* (No. 8) sieve removed. All aggregate material should meet the requirements relating to deleterious substances given in Table 1 of ASTM C 33, "Standard Specification for Concrete Aggregates."

12. Clay supplied as a component material should conform to the chemical and physical requirements of Section 4 of API Specification 13A, "Specification for Oil-Well Drilling-Fluid Materials." Class F fly ash is to be used as a mineral admixture in the cold-cap grout. Fly ash provided as a constituent material for this mixture must meet chemical and physical

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* A table of factors for converting non-SI units of measurement to SI (metric) units is given on page 3.

properties of Class F fly ash as specified in ASTM C 618, "Standard Specifications for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete." No substitution of materials should be permitted during the conduct of the work.

13. The WES-formulated cold-cap grout contains both Type F (high-range water-reducing) and Type B (set-retarding) chemical admixtures. Both types should meet requirements of ASTM C 494, "Standard Specification for Chemical Admixtures for Concrete." Again, we recommend using the same sources of chemical admixtures as found in Appendix A. Brands should not change through preplacement and placement activities.

14. Potable water should be used in the cold-cap grout. Quality testing for potable water is not required. Nonpotable water is not recommended.

Storage and handling

15. The quality of grout produced will depend on the care taken in storage and handling of mixture components. Contamination of materials will cause problems leading to significant changes in desired properties. Precautions must be taken in storage and handling of materials. American Concrete Institute (ACI) *Publication* SP-2, Manual of Concrete Inspection; ACI Committee 304, "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete"; and Portland Cement Association (PCA) Design and Control of Concrete Mixtures contain guidelines, some of which are outlined below.

16. Batch plant bins for cement storage should be weatherproof and well ventilated to prevent accumulation of moisture. Bin vents should be inspected for clogging. Bin interiors should be smooth and of a shape to allow free removal of all cement. Conveyor systems for batching should be separate from the bin. Periodic inspection of the bin interior should be performed to ensure that buildup of cements has not occurred. If buildup is identified, the bin should be cleaned prior to filling with new cement. Care should be taken to prevent exposure of cement to air during storage and handling. Exposure to moisture or carbon dioxide in air can cause cement particle hydration or carbonation to begin, resulting in lumping of cement particles and unacceptable changes in cement properties.

17. Aggregates must be kept as uniform in grading and moisture content as possible and free from contamination during storage and handling. If

aggregates are stored on the ground in piles, the area of storage should be paved or planked to prevent contamination. The area should be leveled and isolated so that contamination from other stockpiles is not likely to occur. Care should be taken to avoid segregation of aggregates while in stockpiles. Excessive handling should be avoided. Storage bins for aggregates should be shaped to ensure uniform discharge for batching. Bins should be loaded by dropping aggregates into the middle of the bin, and bins should be kept as close to full as possible at all times.

18. Fly ash should be stored and handled in essentially the same manner as cement. Tighter storage may be required to prevent leakage in the case of fly ash. ACI 212.3R, "Chemical Admixtures for Concrete," outlines recommended procedures for chemical admixtures. Powdered admixtures should be stored in essentially the same manner as cement, but liquid admixtures should be stored in accordance with manufacturers' recommendations and ACI 212 report.

Testing

19. Materials are inspected and tested to ensure they meet specifications and requirements and are properly stored and handled. Frequency of testing materials will depend on many conditions, most of which can affect the uniformity and moisture content of materials. Some conditions include validity and amount of test data provided by the supplier, the number of production runs used by the supplier to complete the order, storage conditions of the materials, and the amount of handling the material undergoes at the batch plant. Several tests on each material are recommended during selection and acceptance to establish a sufficient statistical base for each material by lot and manufacturer. Sampling must be representative of the material, and procedures should follow ASTM specifications where appropriate. The frequency can be reduced after compliance with specifications is statistically established.

20. Chemical composition of all dry mixture components and mineralogic compositions of all aggregates will be determined. For the demonstration vault, only WHC-approved laboratories will test materials. Characterization of materials for subsequent vaults may be tested in laboratories certified by the Washington State Department of Ecology. Chemical and mineralogic characterization should confirm that grout components used are sufficiently like those of the WES laboratory grout and that comparable performance is

expected. In addition, manufacturers and suppliers should be required to provide test reports on their materials that are in accordance with appropriate ASTM or similar (API) standards and procedures. For example, the cement manufacturer should be required to perform and document cement testing in accordance with ASTM C 183, "Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement." Records should be maintained with the manufacturer, with the contractor, and with WHC. Noncomplying conditions for any lot should be resolved by rejection of the material.

21. All chemical and mineralogic analyses should be archived in permanent project records. Physical samples in sufficient quantity to conduct characterization should be sealed in airtight containers and archived along with original chemical and mineralogic records. Sufficient sample quantities of all accepted materials need to be properly contained and stored for possible future testing and analysis. Written records and reports of inspections and tests must be required. Reports should be maintained beyond the life of the project and, therefore, must be legible, complete, and reliable. Record format and retention procedures should as a minimum comply with those set forth in ACI Manual of Concrete Inspection, ACI Publication SP-2.

22. Prior to placement operations, a trial mixture is recommended for placement in a scale prototype model in the vicinity of the demonstration vault. This task will help ensure adherence to flow, air content, and other required grout properties. The scale model should have greater volume than that conducted in the laboratory environment to compensate for probable differences in properties (especially fluidity) when large-scale commercial equipment is used. We recommend a trial placement to consist of at least two 6-cu-yd batches. Lessons learned from this activity will enable adjustments to the mixture prior to actual placement. This activity also provides an opportunity to evaluate the complete system including laborers, operators, supervisors, inspectors, equipment, and the environment.

23. Prior to a trial batch test, quality assurance inspectors should inspect both the proposed batch plant and mixing trucks. Truck mixers should meet the applicable provisions of ASTM C 94, "Standard Specification for Ready-Mixed Concrete." All scales to be used for weighing materials should

meet the applicable provisions of ASTM C 94 before placement operations begin. Deficiencies noted must be corrected prior to vault grouting activities.

Preconstruction conference

24. We recommend all tasks required before placement of grout be discussed in detail during a preconstruction conference or similar setting. Required materials, testing, equipment, organization, authority, and responsibilities should be some of the major topics. Identification of the contractor's knowledge, equipment, and capabilities should also be discussed and understood. Also important in meeting the grout performance objectives is clarification if required among all organizations involved with placement. These include WHC, the contractor(s), designers, material suppliers, quality control inspectors, and safety inspectors. Each group must understand its role and responsibilities prior to placement. There should be a firm commitment by all parties at the conclusion of this meeting to produce a grout that meets all performance requirements and to make necessary adjustments to operations to meet this goal. Documentation of this task is required in sufficient detail and accuracy that all parties may use it in reference to their operational plans.

Placement Activities

25. The important objective during this phase is to obtain uniformity and homogeneity among all batches of grout as indicated by such physical properties as wet unit weight, flow, nonsegregation, and air content. Prior to placement operations, the major tasks (i.e., batching, transporting, placing) should be identified in real terms such as time, equipment, laborers, and inspectors. This section of our recommendations will outline specific activities to ensure minimum variance with laboratory results of mixture performance and to minimize variability among batches.

Personnel

26. Quality control (QC) inspectors must be certified as indicated in the comprehensive site QA Plan containing specific organizational relationships and assigned authority and responsibilities. There must be a thorough knowledge by all those involved of the grout properties as determined by the laboratory and preplacement activities. These include time of efflux

(flow), workability (pumpability for a minimum time after mixing), temperature effects, bleeding, time of setting, and initial and final wet unit weight.

27. Inspectors from WHC or its representative should be assigned at both the batch plant and at the final delivery site. There should be a sufficient number of inspectors at the batch plant to verify the specified type and amount of cement and other materials used, make necessary acceptance tests, make necessary changes in proportions, observe batching and central mixing, and check the accuracy of batching devices. Inspectors at the batch plant need to have the authority to reject batches that do not have the required properties.

28. Inspectors at the vault site should be in communication with the inspectors at the batch plant. They will also measure grout properties of flow and wet unit weight. Ideally, batches which do not conform to the specifications will be identified and rejected at the batch plant; however, factors such as transit time, temperature, and efficiency of mixing action in each truck can alter batch properties, rendering it unacceptable prior to actual placement. Therefore, the inspectors at the vault site should be aware of initial (batch plant) and final properties prior to the placement and have the authority to reject a nonconforming delivery.

29. All QC inspectors also should be in constant communication with the overall manager of the placement activity. WES representatives will be available for counsel on mixture adjustments and should be in communication with the inspectors and the operations manager. The grouting operations manager should represent WHC and have final responsibility for any decision affecting grout material quality, including mixture adjustments, rejection, and placement.

Testing and inspection

30. Moisture content of the aggregate should be determined each day prior to batching so adjustments to water content can be made in the mixture to maintain the correct water-to-cement ratio as prescribed by laboratory work. Once water is added to a mixture, it cannot be taken out; and no other single material addition can correct for excess water in the grout. The frequency of moisture tests on aggregates will be dictated by the storage conditions and local weather (ambient conditions), but checks should be made often. As a minimum these tests should be done twice a day: the first prior

to batching and again near or immediately after noon. The frequency of the moisture tests on the aggregate will be partly influenced by the expected duration of the particular placement (time in hours/volume in cubic yards). Quality Control inspectors need to inspect continually to assure proper adjustments are made for moisture of aggregates. If the batch plant is equipped with meters that measure the moisture content of starting materials, the calibration needs to be checked and accuracy verified.

31. Immediately after mixing is finished at the batch plant, the wet unit weight (pounds per cubic foot), temperature, volume, flow, and air content should be measured. The wet unit weight and air content are measured onsite as close to the mixer as possible in accordance with ASTM C 138, "Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete." We recommend the wet unit weight should not vary from the results of the prototype trial batches by more than ± 0.2 lb/ft^3. The grout mixture flow properties are measured according to ASTM C 939, "Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)." Time of efflux should be 15 to 18 sec immediately prior to placement. All measurements should be recorded immediately and reported by batch to the site inspectors and the person responsible for placement.

32. In addition to measuring the fresh grout mixture properties already mentioned, the degree of sand suspension or absence of segregation should be determined. There is no standard test procedure for measuring sand suspension. We recommend the inspector place a gloved hand in the fresh mixture and observe for changes in suspension or settling as compared with those observed during the prototype trial batch operation. Due to the alkalinity of the grout, waterproof gloves (surgical quality preferred) should be worn. If settling of sand occurs, the person responsible for placement should be notified immediately, and the batch may be rejected (a sudden increase in aggregate segregation is a likely indicator of excess water in the batch). A modification to the provision for uniformity requirements in ASTM C 94 could also be used as an option for determining the degree of sand suspension per unit volume of material.

33. It is essential to record grout temperature at the batch plant immediately after mixing and at the site prior to placement. Due to the anticipated vault temperature and concern for workability, we recommend a

mixture temperature of less than 90 °F for placement. Record the mixture temperature at the batch plant and at the vault site to monitor the variability of each batch and to maintain mixture uniformity and homogeneity.

34. The most important aspect of testing is the means of securing representative samples for the measurement of each property. All samples (starting materials or fresh grout) for inspection and testing must be truly representative of the population under consideration. Samples should be taken at random and represent the entire batch. Selective sampling should be avoided because this procedure may not be adequately representative. Avoid taking samples at the beginning or the end of mixer truck discharge.

Casting specimens

35. During placement of grout at the vault site, 4- by 8-in. cylinders should be cast and properly maintained for nondestructive evaluation and 28- and 56-day compressive strength testing. Four cylinders per test, three sets for every 150 cu yd of grout, is recommended. In addition, the agency responsible for grout placement should cast 1- by 1- by 11-1/4-in. prisms in accordance with ASTM C 490, "Standard Specification for Apparatus for Use in Measurement of Length Change of Hardened Cement Paste, Mortar, and Concrete." We recommend four prisms be cast per each 150 cu yd of grout placed in the vault. The specimens should be tested for drying shrinkage by ASTM C 157, "Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete."

36. Sampling procedures must be representative of each 150-cu-yd amount of grout placed in the vault. We recommend there be a minimum of two lifts placed in the demonstration vault, with the first lift consisting of approximately 300 cu yd and a second lift of approximately 600 to 700 cu yd of grout. The first lift then would require 48 cast 4- by 8-in. cylinders representing two 150-cu-yd measures. The second lift would then require 96 cast specimens, 24 cylinders for each 150-cu-yd measure. Three or more lifts should be considered.

37. Concrete should be sampled in accordance with ASTM C 172, "Standard Practice for Sampling Freshly Mixed Concrete." Specimens should be made in accordance with ASTM C 31 except that 4- by 8-in. molds will be used and procedures required to account for coarse aggregate are omitted. Molds should meet specified absorption, elongation, and dimensional tolerances of ASTM

C 470, "Standard Specifications for Molds for Forming Concrete Test Cylinders Vertically."

38. As soon as specimens are cast, they should be placed immediately in a protected area onsite under specified temperature conditions simulating average vault conditions. Specimens should not be moved or handled in any manner from the protected area (time of casting) until after final set has occurred (at least 24 hr). At that time, cylinders should be handled in accordance with recommendations stipulated in the Postplacement Activities section of this document.

Equipment

39. During mixing operations it is essential that all materials be uniformly distributed throughout the mixture. Regardless of equipment type selected for mixing operations, mixers must be clean, in good condition, have properly designed blading, not be overloaded, be charged correctly, and be operated at optimum speed as recommended by the manufacturer. Mixers should be inspected for these criteria as well for blade wear and watertightness. If applicable, the batch timer and counter should be checked for proper operation. Sequence of charging the mixer should be determined at the plant with job materials, and this sequence *must be constant* throughout the closure activity.

40. Each truck mixer and agitator should have an attached metal plate with information concerning truck capacity and minimum and maximum rotating speeds (ASTM C 94). If the grout is transit mixed, the volume of the grout should not exceed 63 percent of the total truck volume. If the grout is central mixed, the volume of the grout should not exceed 80 percent of total volume as referenced in ASTM C 94 Section 10.1.2. The truck mixer or agitator should be equipped with counters or other means to verify the number of revolutions before discharge. Standards for truck mixers and agitators are outlined in "Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau," 9th revision, Truck Mixer Manufacturers Bureau.

41. Equipment used to discharge the grout should ensure the material is discharged uniformly and as rapidly as possible into final position without segregation. If pumping equipment will be used, it should be assembled and demonstrated during the trial batch process described in preplacement activities. This will ensure the equipment operates satisfactorily prior to

actual placement. Pipelines are available in many alloys and plastic, but under no circumstance should aluminum piping be used.

Postplacement Activities

42. To verify that hardened grout properties meet requirements established in the laboratory, a number of tests and procedures are recommended during placement and postplacement activities. The minimum requirement is compressive strength testing (ASTM C 39, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens") of cylinder specimens cast during grout placement/vault closure. Prior to testing each specimen for strength, pulse velocity and dynamic modulus can be measured (ASTM C 597, "Standard Test Method for Pulse Velocity Through Concrete"; ASTM C 215, "Standard Test Method for Fundamental Transverse, Longitudinal. and Torsional Frequencies of Concrete Specimens"). Cylindrical specimens could be maintained for long-term monitoring of pulse velocity. A test for volume stability characteristics of the grout could be conducted on cast prisms. For determination of length change, ASTM C 157 is recommended. Specimens may also be cast for test of determination of air-void system, and characteristics of microstructure. Data from measurements of wet unit weight, flow, temperature, and compressive strength will demonstrate compliance of placed grout with the laboratory mixture characteristics and indicate its degree of variability. Two other required actions during this phase of the operation are (a) identification and resolution of noncomplying conditions, and (b) records control and archiving.

Curing, maintaining, and transporting samples

43. Specimens cast in the field are cured there for at least the first 24 hr to allow them to develop adequate strength to be transported. The cylinders should then be transported to the laboratory and again stored in an environment at a specified humidity and temperature selected to simulate average vault conditions. If the shipping environment cannot be controlled, we recommend samples not be removed from the controlled conditions of the site until just before testing. This would ensure early-age strength development in simulated demonstration vault conditions. We recommend cylinders not be

demolded until time of testing. Strength development in the cold-cap grout mixture will be slow. All movement and handling of test specimens during the first few days can significantly alter measured properties.

44. When removed from the site, samples must be adequately protected to prevent damage in transit. If shipped by commercial carrier, samples should be packed in foam rubber or other suitable material with sufficient covering to prevent moisture loss or damage from impact. Early-age specimens (less than 7 days age) must be handled carefully to prevent serious breakage or damage. For movement of samples by vehicle, even for short distances, the samples should be secured in a rack or box so bouncing or falling cannot occur. During the first day after casting, samples should not be handled or moved.

45. Complete information should accompany samples to the laboratory. The information should be securely attached or provide a key to identification numbers secured to each sample. Project, vault, which 150-cu-yd quantity (to identify date and time within mixing records), sample number, complete material identification including type and grade, source, date of sampling, quantity represented, location in structure (lift number), test required, and shipper's identification should be included with sample information including truck number and relative information from the truck batch ticket.

Properties testing and frequency

46. Tests on mixture components and on grout should be conducted throughout all phases of cold-cap grout application for reasons already stated. A summary of these recommended tests and their frequency is tabulated in Appendix B. These tests are only the minimum recommended, and the final authority for testing and frequency must be stated in the comprehensive QA plan.

47. We recommend that the properties of the field-cast cylinders of grout from vault closure be verified by two independent laboratories. Duplication of effort will demonstrate a higher probability of accuracy in determining actual in-place properties and verification of compliance with mixture design. It is recommended that this verification be accomplished by sending one cylinder selected at random from each set of four to an independent laboratory.

Identification and resolution
of noncomplying conditions

48. ACI 121R, "Quality Assurance Systems for Concrete Construction" outlines the importance and also the complicated nature of addressing noncomplying conditions. Materials or processes which do not meet project requirements as specified in contractual documents should be promptly identified and evaluated for implementation of corrective action. Appendix B states our recommended limits to mixture components and grout properties at the batch facility, onsite, and in the hardened state. At the batch facility and onsite, noncomplying conditions must be defined for material which does not meet stated specifications.

Records control and archiving

49. Each organization generating records or documents that furnish evidence of the quality of materials, equipment, or activities should be responsible for their technical content, completeness, and accuracy. All documents need to be authenticated by being signed and dated by a responsible individual from the organization initiating the record. WHC should implement a program for ongoing review of records and reserve the right for access to all applicable records and documents.

50. All records, written descriptions of deviations from planned activities, and mixture component samples should be archived for a duration defined by WHC. A designated organization must have assigned responsibility for maintaining complete cards, reports, and samples for the storage period. Care must be observed in including detailed as-built conditions and descriptions in the records for future reference.

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____________. 1992b. "Grout for Closure of the Demonstration Vault at the U.S. DOE Hanford Facility," Technical Report SL-92- (in preparation), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

APPENDIX A: MATERIALS AND SUPPLIERS

1. Materials and suppliers used during WES cold-cap grout development include:

Material	Type	Supplier/Manufacturer
Cement	Class H	Lone Star Industries FM 608 Maryneal, TX 79535 1-800-541-7734
Fly Ash	Class F Centralia	Ross Island Sand and Gravel Dry Mix Division 4315 S.E. McLoughlin Blvd Portland, OR 97202
Fine Aggregate	Sand, ASTM C 404	ACME Concrete Company 955 Lacy Road Richland, WA 99352
High-Range Water-Reducing Admixture	DAXAD 19® Sodium Naphthalene Sulphonate Formaldehyde Condensate	W R Grace and Company 62 Whittemore Avenue Cambridge, MA 02140
Set-Retarding Admixture	Plastiment® Salt of Hydroxylated Carboxylic Acid	Sika Chemical Corporation 875 Valley Brook Avenue Lyndhurst, NJ 07071

APPENDIX B: MATERIALS TESTING AND INSPECTION

1. During preplacement activities starting materials should be inspected and tested as follows:

Material	Tests	Frequency	Specification
HSR Oil-Well Cement	As required by the applicable specification plus additional tests as required by ASTM C 150 for Type V	Each lot of material and as needed when storage conditions change	API Oil-Well Cement (Type H (HSR))
Class F Fly Ash	As required by ASTM C 618 for Class F	As required by ASTM C 618 for Class F	ASTM C 618-91 (Class F)
Sodium Bentonite Clay	Chemical and Physical Characterization	Sample from each lot of material	API Spec 13A Section 4
Sand	As required by applicable specification	As required by applicable specification	ASTM C 404 for Natural Sand Size No. 2, with no material retained on 2.36-mm (No. 8) sieve
Chemical Admixtures	ASTM C 494, Types B and F as required by applicable specification	As required by applicable specification	ASTM C 494, Types B and F

2. During batching activities, starting materials and fresh grout should be inspected and tested as follows:

Material	Tests	Frequency	Specification
Sand	ASTM C 566* Moisture Content	Twice daily	None
Grout	ASTM C 939 Flow	Immediately after Batching	Time of efflux between 15 to 18 sec
Grout	ASTM C 138 Unit Weight, Air Content	Immediately after Batching	Values to be selected during Trial Batch Tests
Grout	ASTM C 1064	Immediately after Batching	90 °F or less
Grout	Segregation	Immediately after Batching	Not excessive

3. During onsite placement activities, fresh grout should be inspected and tested as follows:

Material	Tests	Frequency	Specification
Grout	ASTM C 939 Flow	Immediately before Pour	Time of efflux 15 to 18 sec
Grout	ASTM C 138 Unit Weight, Air Content	Immediately before Pour	Values to be selected during Trial Batch Tests

Material	Tests	Frequency	Specification
Grout	Temperature	Immediately before Pour	90 °F or less
Grout	Segregation	Immediately Before Pour	None

* ASTM C 70, "Standard Test Method for Surface Moisture in Fine Aggregate," is not considered a suitable alternative to ASTM C 566.

4. During postplacement activities, hardened state grout should be tested as follows:

Material	Tests	Frequency	Specification
Grout	ASTM C 39 Comp. Strength	28, 56 day	TBD
Grout	ASTM C 157 Length Change	28, 90 day	TBD

Waterways Experiment Station Cataloging-in-Publication Data

Harrington, Patrick T.
Quality assurance plan for placement of cold-cap grout, demonstration vault, Hanford Grout Vault Program / by Patrick T. Harrington ... [et al] ; prepared for U.S. Department of Energy, Oak Ridge Field Office.
25 p. : ill. ; 28 cm. — (Technical report ; SL-92-20)
Includes bibliographic references.
1. Radioactive waste disposal in the ground — Testing. 2. Grout (Mortar) I. Harrington, Patrick T. II. United States. Dept. of Energy. Oak Ridge Operations Office. III. U.S. Army Engineer Waterways Experiment Station. IV. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; SL-92-20.
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